Displacement Damage Testing of OMR9701 Using 198 MeV Protons

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29th October 2003

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1. Introduction

The OMR9701 Dual Solid State Relay was tested for displacement damage using 198 MeV protons at the Indiana University Cyclotron Facility. It is a radiation hardened device (100 krad(Si)) for which radiation testing was performed with gamma rays in a Co^{60} cell. Each of the two solid state relays in the package contains an optocoupler whose radiation-induced degradation may be dominated by displacement damage. Therefore, it was deemed necessary to test the device for displacement damage using protons.

2. Devices

Two devices were tested. The data and lot codes were.

Figure 1 shows a simplified schematic diagram of the dual OMR9701.

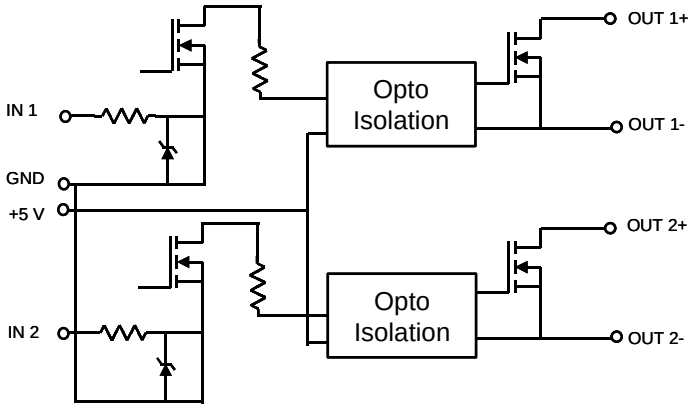

Figure 1. Simplified schematic diagram of the OMR9701 solid state relay showing the opto-isolators consisting of optocouplers.

3. Test Procedure

Devices were positioned in front of the beam port for irradiation. They were unbiased and the legs were pressed into conducting foam to prevent charge buildup. After exposure they were removed to the experiment control area to measure their electrical parameters.

4. Parameters Measured

The electrical parameters of each of the two solid state relays were measured independently. Two configurations were used: i) device on and ii) device off. Applying a 5 V bias to an input turned the device on and grounding the input turned it off. A load of 75 V was applied to an output of each device. Because the electronic load we used could not handle 75 V, a resistor network was combined with the electronic load, such that there was a 60 V drop across the electronic load and a 15 V drop across the resistors. By measuring both the voltage drop between OUT(+) and OUT(-) and the current flow through the electronic load, the resistance of the output MOSFET could be measured as a function of proton fluence.

5. Results

Tables I-IV show the results of measurements of relevant parameters following incremental fluences(doses) for four devices (two dual parts). With the device turned off there is no leakage current either through the supply or the load, and there is no drop in the load. When the device is turned on the leakage currents in the supply, input and load were measured. Also the load voltage was measured for calculating the output resistance.

Table I
Parametric Measurements for OMR9701 DUT 32A

	Device OFF			Device ON				
Fleuence/TID #/cm^2/krad(Si)	I(load) mA	Icc mA	V(load)	I(load) mA	Icc mA	I(In) MA	V(load)	R(out) ohms
0/0	0	0	75	4.52	10.3	0	0.369	0.082
1.67x10^{11}/10	0	0	75	4.52	10.3	0	0.375	0.082
3.34x10^{11}/20	0	0	75	4.52	10.3	0	0.370	0.082
5.01x10^{11}/30	0	0	74.9	4.52	10.3	0	0.379	0.084
6.68x10^{11}/40	0	0	74.9	4.52	10.3	0	0.379	0.084
8.35x10^{11}/50	0	0	74.9	4.52	10.3	0	0.379	0.084
1.25x10^{12}/75	0	0	74.9	4.52	10.3	0	0.383	0.085
1.67x10^{12}/100	0	0	74.9	4.52	10.3	0	0.386	0.085

Table II
Parametric Measurements for OMR9701 DUT 32B

	Device OFF			Device ON				
Fleuence/TID #/cm^2/krad(Si)	I(load) mA	Icc mA	V(load)	I(load) mA	Icc mA	I(In) MA	V(load)	R(out) ohms
0/0	0	0	74.9	4.52	10.3	0	0.373	0.083
1.67x10^{11}/10	0	0	75	4.52	10.3	0	0.378	0.084
3.34x10^{11}/20	0	0	74.8	4.52	10.3	0	0.389	0.086
5.01x10^{11}/30	0	0	74.9	4.52	10.3	0	0.384	0.085
6.68x10^{11}/40	0	0	74.8	4.52	10.3	0	0.379	0.084
8.35x10^{11}/50	0	0	74.9	4.52	10.3	0	0.387	0.086
1.25x10^{12}/75	0	0	74.9	4.52	10.3	0	0.393	0.087
1.67x10^{12}/100	0	0	74.9	4.52	10.3	0	0.041	0.091

Table III
Parametric Measurements for OMR9701 DUT 54A

	Device OFF			Device ON				
Fleuence/TID #/cm^2/krad(Si)	I(load) mA	Icc mA	V(load)	I(load) mA	Icc mA	I(In) MA	V(load)	R(out) ohms
0/0	0	0	74.9	4.52	10.3	0	0.385	0.085
1.67x10^{11}/10	0	0	74.9	4.52	10.3	0	0.396	0.088
3.34x10^{11}/20	0	0	74.8	4.52	10.3	0	0.402	0.089
5.01x10^{11}/30	0	0	74.9	4.52	10.3	0	0.396	0.088
6.68x10^{11}/40	0	0	74.9	4.52	10.3	0	0.391	0.087
8.35x10^{11}/50	0	0	74.9	4.52	10.3	0	0.399	0.088
1.25x10^{12}/75	0	0	74.9	4.52	10.3	0	0.414	0.092
1.67x10^{12}/100	0	0	74.9	4.52	10.3	0	0.449	0.099

Table IV
Parametric Measurements for OMR9701 DUT 54B

	Device OFF			Device ON				
Fleuence/TID #/cm^2/krad(Si)	I(load) mA	Icc mA	V(load)	I(load) mA	Icc mA	I(In) MA	V(load)	R(out) ohms
0/0	0	0	74.9	4.52	10.3	0	0.374	0.083
1.67x10^{11}/10	0	0	74.9	4.52	10.3	0	0.382	0.085
3.34x10^{11}/20	0	0	74.8	4.52	10.3	0	0.386	0.085
5.01x10^{11}/30	0	0	74.9	4.52	10.3	0	0.387	0.086
6.68x10^{11}/40	0	0	74.9	4.52	10.3	0	0.386	0.085
8.35x10^{11}/50	0	0	74.9	4.52	10.3	0	0.389	0.086
1.25x10^{12}/75	0	0	74.8	4.52	10.3	0	0.423	0.094
1.67x10^{12}/100	0	0	74.9	4.37	10.7	0	2.73	0.062

6. Conclusions

All four devices pass all tests up to 100 krad(Si). Only at 100 krad(Si) did one of the dual parts degrade significantly.